Aneurysm of an aberrant right subclavian artery: Treatment with PTFE covered stentgraft

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Hunald[1] first described aberrant subclavian artery on necropsy in 1735. The anomaly most commonly involves the right subclavian artery, or rarely the left subclavian artery when there is a right-sided aortic arch. Aberrant right subclavian artery occurs in up to 1% of the population, and originates from a diverticulum originally described by Kommerell.[2] Aneurysmal change in this vessel is rare, with only 53 cases reported in the literature.[3] The natural history of these aneurysms is similar to those elsewhere, with continued expansion common. Several cases have presented with rupture and subsequent death, and the consensus in the surgical literature supports early elective resection.[4] Transluminally placed stent grafts offer an alternative approach to standard treatments for a variety of vascular pathologies. The clinical feasibility of transluminal endovascular grafting for the treatment of abdominal aortic aneurysm, thoracic aortic aneurysm, subclavian artery aneurysm, arteriovenous fistula, and femoral occlusive disease is well documented.[5-7]

These newer procedures are less invasive and potentially less expensive, with a lower risk than standard operative repair. We report the first case of an aneurysm of an aberrant right subclavian artery treated successfully using a polytetrafluoroethylene (PTFE) covered stent graft.

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CASE REPORT

We were referred an 80-year-old male retired anatomy professor, with a slowly expanding right paratracheal mass, for further evaluation. A preoperative chest radiograph initially detected the abnormality 3 years earlier (Fig. 1). Follow-up radiographs during the next 36 months documented a doubling in the size of the lesion (Fig. 2). He complained of occasional mild dysphagia for solid food, but was otherwise asymptomatic. His medical history was significant for a remote history of cigarette smoking, carcinoma of the prostate, and adequately controlled hypertension. Physical examination was non-contributory, with symmetric arm pulses.

Initial evaluation included a contrast-enhanced computed tomography scan of the chest and a thoracic aortogram. These showed an aberrant right subclavian artery originating from a prominent diverticulum of Kommerell. A 5.4 cm diameter aneurysm of the right subclavian artery was evident distal to this diverticulum, and separated from it by a 1 cm segment of normal caliber artery (Figs. 3 and 4).

PROCEDURE

The Investigational Review Board fully approved the procedure, and we obtained informed consent from the patient. After computed tomography and arteriographic determinations of the length, diameter, and tortuosity of the subclavian artery aneurysm, and the proximal and distal necks, we custom fabricated a tapered PTFE covered stent graft. The stent graft was composed of modified Gianturco-Z stents (Cook Inc., Bloomington, Ind), sutured together with 2-0 polypropylene suture. The device tapered in diameter from proximal (24 mm) to distal (13 mm) and measured 11 cm in length. We dilated an 8 mm diameter segment of thin-wall PTFE graft material (Impra Inc., Tucson, Ariz) with various angioplasty balloons to achieve a tapered covering that matched the dimensions of underlying stent framework. The PTFE was then sutured to the ends of the stent with

Fig. 1. Chest radiograph taken 3 years before presentation shows an abnormal curvature superior to the aortic knob, which correspond to the diverticulum of Kommerell. The right paratracheal region is normal.

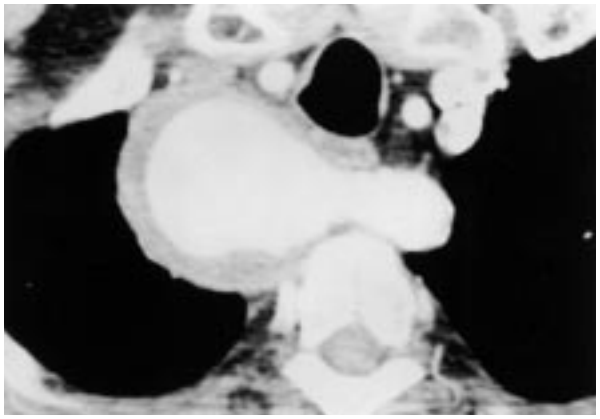

Fig. 3. Computed tomography scan shows the aberrant right subclavian artery passing posterior to the trachea and esophagus, becoming aneurysmal to the right of the midline. Maximal diameter of the aneurysm is 5.4 cm.

Fig. 2. Chest radiograph shows a new right paratracheal mass.

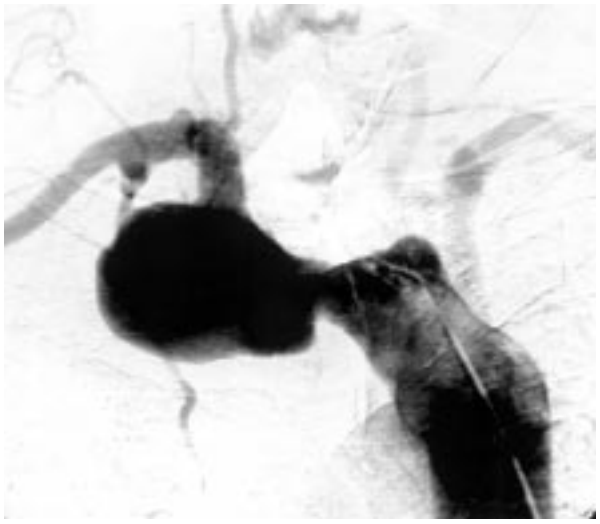

Fig. 4. Subtraction arteriography after selective catheterization of the diverticulum of Kommerell shows the aberrant right subclavian artery, with the aneurysm in the portion of the vessel proximal to the right vertebral artery origin.

6-0 polypropylene suture and the entire device gas sterilized by an ethylene oxide process (Fig. 5).

After an initial thoracic aortogram through a right common femoral artery puncture, we performed selective catheterization of the diverticulum of Kommerell using a catheter with a pre-formed hockey stick shape. We manipulated a torqueable 0.035-inch guidewire (Glidewire, Meditech, Watertown, Mass), through the lumen of the aneurysm into the distal right axillary artery. We then exchanged the guidewire for a 260-cm long stiff 0.035-inch guidewire (Amplatz Super-Stiff, Meditech). We sequentially dilated the right femoral artery percutaneous access site using vascular dilators to 18F diameter. We advanced an 80-cm, 18F Teflon sheath and polyethylene dilator combination (Cook Inc) over the stiff guidewire until the tip of the sheath was in the normal distal subclavian artery. We groomed the sterilized stent graft into an 18F Teflon introducer. We then introduced it into the sheath using a blunt-tipped polyethylene mandrill as a pusher, and advanced to a position bridging the aneurysm. We then withdrew the sheath, and deployed the stent graft.

Post-deployment arteriography showed minimal persistent perigraft flow within the aneurysm, and excellent flow through the stent graft into the right

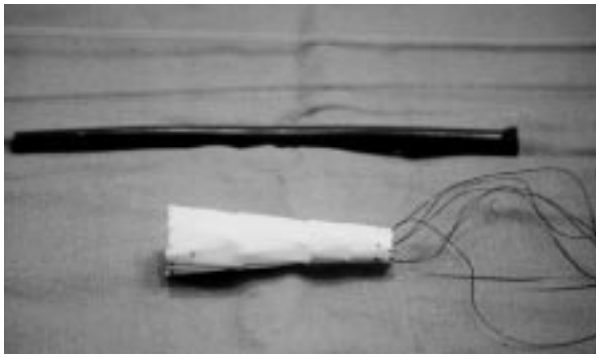

Fig. 5. PTFE covered stent graft tapering from 24 mm to 13 mm in diameter, and measuring 11 cm in length.

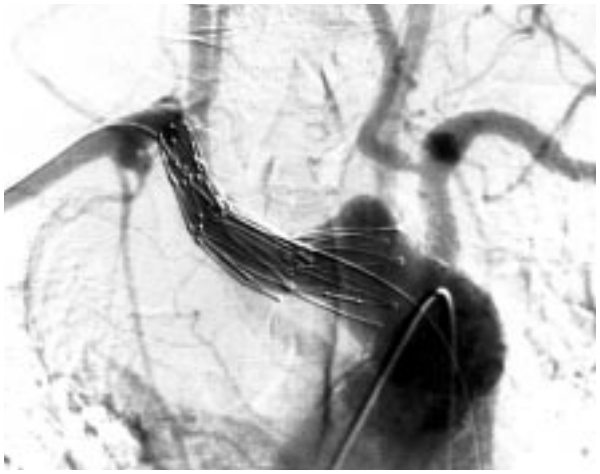

Fig. 6. Post-deployment aortogram shows flow through the stent graft in the aberrant right subclavian artery with exclusion of the aneurysm. Antegrade flow is seen in the right vertebral artery.

vertebral, distal subclavian, and axillary arteries. Subsequently, we inflated a 24-mm valvuloplasty balloon (Braun Inc., Bethlehem, Penn) within the proximal stent body of the stent graft. After a repeated arteriogram, no further filling of the aneurysm was evident (Fig. 6). We then removed the 18F sheath and surgically closed the arteriotomy site. The day after the procedure, a computed tomography scan showed no evidence of perigraft contrast media and complete thrombosis of the aneurysm sac surrounding the stent graft (Fig. 7). Repeated computed tomography scan 1 year after stent graft placement shows persistent thrombosis, with reduction (a 30% decrease) in the maximal diameter of the aneurysm from 5.4 cm to 3.8 cm (Fig. 8).

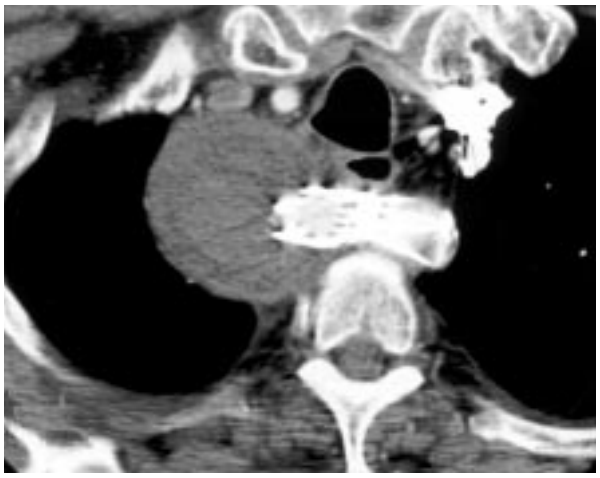

Fig. 7. Computed tomography scan shows flow in the stent graft lumen with thrombosis of the aneurysm.

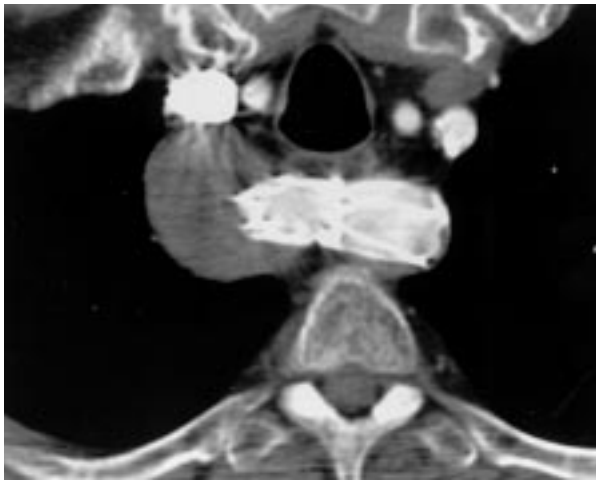

Fig. 8. Repeated computed tomography scan 1 year after stent graft placement shows persistent thrombosis of the aneurysm. Maximal diameter of the aneurysm is 3.8 cm.

DISCUSSION

An aberrant right subclavian artery is the most common arch anomaly, occurring in approximately 0.5% to 1.0% of the population.[8] The abnormality is caused by the anomalous obliteration of the right fourth aortic arch during embryologic development. Consequently, the right subclavian artery takes its origin from the aorta distal to the left subclavian artery and crosses the midline to reach the right arm. In most cases, the artery courses behind the esophagus, although it can course between the esophagus

and trachea, and even anterior to the trachea.[9] In 60% of cases, the aberrant right subclavian artery arises from a saccular outpouching of the aorta, referred to as "Kommerell's diverticulum."[2] This diverticulum represents an incomplete regression of the primitive right aortic arch, and is distinct from diverticula associated with obliteration of the ductus arteriosus, or an aberrant left subclavian artery.[10]

Aberrant right subclavian artery most commonly presents incidentally on chest radiograph, or at endoscopy.[8] The most common complaint from an aberrant right subclavian artery, irrespective of an associated aneurysm, is dysphagia. In 1794, David Bayford used the phrase "dysphagia lusus naturae" (dysphagia caused by a freak of nature) when describing this symptom.[9]

McCallen first described aneurysmal enlargement of an aberrant right subclavian artery in 1956, 20 years after Kommerell's initial description of the vessel's origin.[11] It is rare, having been described in only 53 patients.[4] Approximately 90% of these aneurysms are due to atherosclerosis, and 25% are associated with aneurysms elsewhere, most notably, the aorta.[4]

Confusion exists surrounding the differentiation of a normal diverticulum at the vessel's origin, and a true aneurysm. In 1989, Felson addressed this issue and divided the entity into three categories: the normal diverticulum described by Kommerell, aneurysmal dilatation of this diverticulum and aneurysm of the distal vessel separated from the diverticulum or aorta by a segment of normal caliber subclavian artery.[10] Most of the reported cases of aberrant right subclavian artery aneurysm have been either "normal" or enlarging diverticula. However, there has been no attempt to define the size limits of a "normal" diverticulum.

The presenting features of aberrant right subclavian aneurysm are similar to those of the normal sized vessel, with the notable exception of acute vessel rupture. More than 50% of cases of aneurysmal aberrant subclavian artery treated with conservative management have ruptured.[4] This complication is associated with a high mortality, and current recommendations are for early surgical repair. Campbell[12] reported the first surgical repair in 1971. Because the preoperative diagnosis was a mediastinal tumor, the physician did not expect the finding of an aneurysm. The physician successfully treated this patient by interposing a customized polyester aortoiliac graft. Since that time, physicians have used many different operative approaches. Some have used Campbell's technique; others have ligated the aneurysm and anastomosed the right carotid artery to the distal right subclavian vessel[13]. In a review by Austin and Wolfe in 1985, 20 of 32 patients with aberrant subclavian aneurysms underwent surgery, with a mortality rate of 11%.[4] Of the 12 patients who did not undergo surgical repair, two were lost to follow-up, three died from unrelated pathology and two were alive and well at the time of the article. Five (41%) died of aneurysm rupture; four ruptured their subclavian artery aneurysms; and one ruptured an abdominal aortic aneurysm. These figures strongly support the need for early definitive intervention to prevent rupture.

Endovascular stent grafts have been used to treat various pathologies, including thoracic and abdominal aortic aneurysms, iliac artery aneurysms, subclavian artery aneurysms, arteriovenous fistula, and femoral occlusive disease.[5-7,14,15] Reports of stent graft treatment of subclavian artery "aneurysms" have dealt exclusively with pseudoaneurysms involving arteries originating from the aorta in the expected anatomic location—in the setting of iatrogenic or penetrating traumatic injuries.[16] To our knowledge, no report has described treatment of an aberrant right subclavian artery aneurysm by placement of an endovascular stent graft.

The anatomic and technical considerations that complicated treatment of the aneurysm in this case presented some interesting challenges.

The images from the aortogram and computed tomography (Figs. 3 and 4) show the tortuous course of the right subclavian artery from the left side of the thorax, posterior to the esophagus, and then superior to reach its normal anatomic location. It was necessary for the deployed stent graft to conform to this S-shape configuration with the proximal aspect of the stent graft anchored within the diverticulum of Kommerell and the distal stent graft within the subclavian artery just proximal to the origin of the right vertebral artery.

A mismatch in the diameters of the proximal and distal "necks" required custom construction of a tapered stent graft. This was accomplished by sequentially balloon dilating a segment of 8 mm thin-wall PTFE graft material so the final length of the graft tapered from 24 mm at the proximal end to 13 mm at the distal end. The combination of the graft material fully supported by an endoskeleton of interconnected Z-stents provides a smoothly tapered semi-flexible device that accommodates the curve of the artery without kinking or buckling.

After deployment, an arteriogram showed a small area of perigraft filling of the aneurysm with contrast

media. We sealed this by dilating the stent graft with a 24-mm valvuloplasty balloon catheter to promote improved apposition between the stent graft and the aneurysmal neck. Repeated arteriography post-dilation confirmed creation of a tighter seal with obliteration of the perigraft leak. In other cases of leaks after stent graft placement for the treatment of aneurysms, patients have undergone transcatheter embolization using embolic coils with successful exclusion of perigraft flow.[17] The absence of any continued expansion of the aneurysm at a 1-year follow-up in this case, along with a reduction in size of the thrombosed sac, indicates complete exclusion of flow (Fig. 8).

With advances in computed tomography and magnetic resonance imaging, we will be able to diagnose these uncommon aneurysms earlier and more frequently than in the past. The natural history of these lesions is similar to that of aneurysms occurring elsewhere, with progressive enlargement and rupture. Surgical repair of an aneurysm of this extent would require a thoracotomy to control the retroesophageal portion and a supraclavicular incision for the contralateral reconstruction. Preliminary experience with endovascular treatment of arterial aneurysms occurring elsewhere in the circulation has been encouraging, with reduced morbidity compared to surgery. We describe the first successful treatment of an aberrant right subclavian artery aneurysm with a PTFE covered stent graft.

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